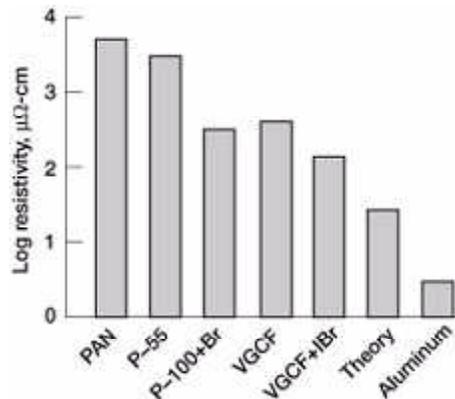


Highly Conducting Graphite Epoxy Composite Demonstrated

Weight savings as high as 80 percent could be achieved if graphite polymer composites could replace aluminum in structures such as electromagnetic interference shielding covers and grounding planes. This could result in significant cost savings, especially for the mobile electronics found in spacecraft, aircraft, automobiles, and hand-held consumer electronics. However, such composites had not yet been fabricated with conductivity sufficient to enable these applications.

To address this lack, a partnership of the NASA Lewis Research Center, Manchester College, and Applied Sciences, Inc., fabricated nonmetallic composites with unprecedented electrical conductivity. For these composites, heat-treated, vapor-grown graphite fibers were selected which have a resistivity of about $80 \mu\Omega\text{-cm}$, more than 20 times more conductive than typical carbon fibers. These fibers were then intercalated with iodine bromide (IBr). Intercalation is the insertion of guest atoms or molecules between the carbon planes of the graphite fibers. Since the carbon planes are not highly distorted in the process, intercalation has little effect on mechanical and thermal properties. Intercalation does, however, lower the carbon fiber resistivity to less than $10 \mu\Omega\text{-cm}$, which is comparable to that of metal fibers.

Scaleup of the reaction was required since the initial intercalation experiments would be carried out on 20-mg quantities of fibers, and tens of grams of intercalated fibers would be needed to fabricate even small demonstration composites. The reaction was first optimized through a time and temperature study that yielded fibers with a resistivity of $8.7 \pm 2 \mu\Omega\text{-cm}$ when exposed to IBr vapor at 114°C for 24 hours. Stability studies indicated that the intercalated fibers rapidly lost their conductivity when exposed to temperatures as low as 40°C in air. They were not, however, susceptible to degradation by water vapor in the manner of most graphite intercalation compounds. The 1000-fold scaleup experiments concluded that 114°C was near the optimum temperature, but that the intercalation time needed to be lengthened by a factor of 3.



Composite resistivity of different graphite fibers.

Laminar composites were hand laid up with the graphite fibers and two different resins, a room temperature epoxy and a cyanate ester resin with a cure temperature of 175 °C. The resistivity of the resulting composites was $200 \pm 25 \mu\Omega\text{-cm}$, nearly a factor of two lower than for similar composites made with intercalated pitch-based fibers. The fibers in the cyanate ester composites did not appear to lose conductivity even though the cure temperature was well above the temperature at which the fibers lost conductivity in air. Although this is the lowest resistivity composite yet fabricated, calculations indicate that it should be possible to use these fibers to make composites that are 6 to 7 times more conductive.

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Programs/Projects: High-conductivity, low-weight applications, such as notebook computers and cell phones